NASA Science Mission Directorate - Applied Sciences Program

Air Quality Management – Fiscal Year 2005 Annual Report [*]

SUMMARY

The Air Quality Management program element accomplished major milestones and made significant progress in 2005 to support the use of Earth science results, especially Earth science models, in air quality management. The Air Quality team completed a benchmark report on the use of model-derived lateral boundary conditions in EPA's Community Multiscale Air Quality model (CMAQ), and the team completed another benchmark report on the use of land-use models and data in CMAQ. The team worked with EPA and NOAA to successfully transition to operations the use of MODIS aerosol measurements in their air quality forecast activities. In addition, the Air Quality (AQ) team increased its involvement in international air quality activities, such as long-range transport of pollutants, and with national interagency air quality initiatives, such as the U.S. Group on Earth Observations. The Air Quality program received excellent proposals through the Decisions CAN, adding two long-term projects and one short-term project to its portfolio.

NASA, partner organizations, and members of the Air Quality team were honored for their contributions to air quality forecasting activities with the cover of the September 2005 *Bulletin of the American Meteorological Society.* In addition, the Air Quality application team received a NASA Group Achievement Award in June 2005.

MAJOR ACCOMPLISHMENTS

Transition of MODIS Aerosol Forecast Prototype to EPA/NOAA

Building on the prototype and benchmark report this project completed in FY04, NASA, EPA and NOAA supported the transition of the MODIS Aerosol Forecast, which supports EPA's Air Quality Index, to a near-operational setting based at the Cooperative Institute of Meteorological Satellite Studies (CIMSS, which is a joint NOAA-NASA-University of Wisconsin institute). CIMSS now produces forecast guidance daily, and it issues forecasts within 4 hours of a MODIS image. EPA and NOAA will continue operating the system, training forecasters, and using the tool to support their forecasting responsibilities. *http://idea.ssec.wisc.edu/*

Benchmarked the Use of Globally Assimilated Lateral Boundary Conditions to Improve CMAQ Ozone Estimates

NASA and EPA completed this multi-year project to provide and assess lateral boundary conditions generated from a global model output to CMAQ. CMAQ was originally developed for regional scale domains, and this project focused on the use of a multi-scale modeling and data assimilation framework to improve the prediction of large-scale transport and local productions of surface ozone and overall CMAQ performance. The project involved two global ozone assimilation frameworks – Regional Air Quality Modeling System (RAQMS; NASA LaRC-University of Wisconsin) and the Finite Volume Data Assimilation System (FvDAS; NASA GSFC). The project identified that improvements to the vertical resolution of CMAQ and improvements in the convective exchange processes in the middle to upper troposphere may optimize benefits to CMAQ performance from using assimilated lateral boundary conditions. The upper tropospheric ozone concentrations from CMAQ/RAQMS showed increases of up

[*] The FY05-09 Air Quality Program Element Plan is available through: *http://aiwg.gsfc.nasa.gov/dss.html*

to 200 ppbv compared to those with the CMAQ/Baseline boundary conditions; CMAQ/RAQMS was in better agreement with ozonesonde observations (100 – 400 ppbv). There were no significant differences in the surface distributions of ozone during the benchmark period between CMAQ/Baseline and CMAQ/RAQMS. These results provided guidance for future CMAQ development plans as part of NOAA's 2005 Air Quality Forecasting System Design Review.

Note: As part of the project, U.S. EPA graciously agreed to modify Models-3/CMAQ to accept time- and spatially-varying lateral boundary conditions from NASA models and to conduct evaluations of CMAQ performance. These actions are significant indications of EPA's commitment as a partner and the success NASA researchers have had in developing and nurturing interagency partnerships.

Benchmarked the Use of Growth Models and Land Use Data to Improve Urban Air Quality Model Forecasts

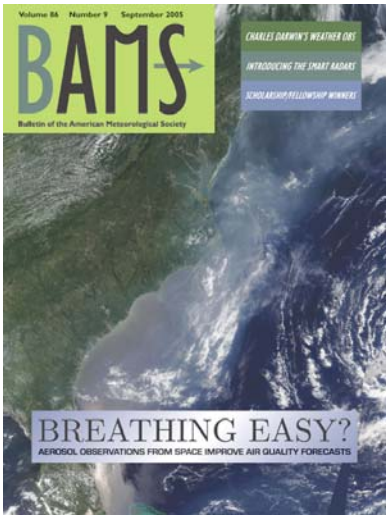
NASA, EPA, and several regional/local organizations completed this multi-year project near Atlanta to assess the use of a land-use growth model (Spatial Growth Model, SGM) and land characteristic data (LandPro99 merged with National Land Cover Data from Landsat) with CMAQ/Models-3 (including MM5 and SMOKE) to improve management options in developing State Implementation Plans (SIP) to meet the National Ambient Air Quality Standards (NAAQS). The specification of land use, which affects land surface energy and water fluxes, affects the near-surface meteorology and emissions. Current tools use numerical models to simulate the physical/chemical processes that govern the formation and transport of criteria pollutants and their precursors. The NLCD/LandPro99 data provide a more accurate representation of the current land use, and the data allow a more robust assessment of future land use changes through the use of SGM.

The project found that use of the high-resolution data improved performance of the MM5 meteorological model substantially compared to the use of traditional land-use data, with the overall daytime cold bias reduced by over 30%. However, the CMAQ air quality model performance for ozone did not show an improvement (increased boundary layer mixing simulated with high-resolution land-use data negated the effects of warmer near-surface air temperatures). In addition, the project used SGM-projected land use changes through 2030 in modeling simulations, which predicted higher urban air temperatures. The incorporation of urban heat island mitigation strategies (e.g., highly reflective roofing and increased tree canopy) proposed by local stakeholder groups partially offset this warming trend.

BAMS Cover for MODIS-based Enhancements to Air Quality Forecasting

Researchers from the NASA Air Quality team, NOAA, EPA, industry, and academia published a paper on the team's air quality forecasting project in the *Bulletin of the American Meteorological Society (BAMS, Sept. 2005, 86: 1249-1261).* The paper "Improving National Air Quality Forecasts with Satellite Aerosol Observations" was the cover story for the September 2005 issue.

Authors included J. Al-Saadi, J. Szykman, R. B. Pierce, C. Kittaka, D. Neil, D. A. Chu, L. Remer, L. Gumley, E. Prins, L. Weinstock, C. MacDonald, R. Wayland, F. Dimmick, and J. Fishman. *http://www.ametsoc.org/pubs/bams/*



ADDITIONAL ACHIEVEMENTS

The following were significant achievements and developments for the Air Quality application team:

- REASoN Project: DataFed. The DataFed infrastructure provided direct, just-in-time support for the EPA rule-making process for Exceptional Events (Docket EPA-HQ-OAR-2003-0061, National PM-2.5 Designations). The project used DataFed data and analysis tools to evaluate 42 "exceptional aerosol events" for EPA (events flagged by States as being "extra-jurisdictional smoke"). The official docket for the rule-making includes the resulting analysis report, which explicitly and widely used data from MODIS, SeaWiFS and TOMS. *http://datafed.net/* and *http://www.regulations.gov/*
- The GSFC Land Information Systems (LIS) group continued work to extend land-atmosphere and biochemical deposition model products and capabilities for use in EPA CMAQ, particularly land-atmosphere ammonia (NH_3) exchanges. The LIS project uses the MODIS land cover (MOD12) and leaf area index (MOD15) in extending land surface model products to EPA on air quality (and water) issues. LIS work in FY05 examined potential bi-directional fluxes of ammonia, which could identify limitations in the CMAQ modeling approach. *http://lis.gsfc.nasa.gov/*
- NASA (through the Air Quality program) sponsored a special session at the 98th Air & Waste Management Association (AWMA) in Minneapolis. The session focused on long-range aerosol transport events, examining the use of satellite observations to support air quality management. NASA also sponsored a booth in the exhibit hall and displayed Earth science atmospheric chemistry data; the Air Quality program shared the booth with NASA Kennedy Space Center, which presented some of NASA's technology transfer activities).
- Battelle Memorial Institute, through a cooperative agreement between NASA-GSFC and University of Maryland-Baltimore County, completed a report on international air quality treaties, including the identification of opportunities to extend NASA Earth science products to air quality policy activities. The report focused primarily on descriptions and potential NASA Earth science results for the *Convention on Long-Rang Transboundary Air Pollution (LRTAP)* and the *U.S.-Canada Bilateral Air Quality Executive Agreement*.
- Work began on the project *Toward the Development of Advanced Data Products from EOS Terra and Aqua Direct Broadcasts for Air Quality Management in the State of Texas*, which was selected through the EOS Continuation NRA in FY04 (PI: K. Hutchinson, U. Texas-Austin). The project focuses on the development of cloud parameters in models for air quality. In FY05, the project made significant improvement in retrieving cloud boundaries (i.e., cloud top bases and heights) from MODIS data, using a new approach developed for air quality modeling applications. Compared to more conventional methods, the new approach reduces errors by an average of 50% (relative to truth). In addition, the project identified that the current MODIS interpolation scheme, which is used to convert between these cloud top parameters, does not adequately consider errors in retrieved cloud top temperatures or effectively utilize moisture profiles in the NCEP analysis fields to make these conversions.
- The program's Biomass Emissions project delivered satellite-derived fire products for 2002 (EPA's evaluation year), supporting EPA's and Regional Planning Organizations' (RPO) abilities to estimate biomass-burning emissions in a timely and economic manner. The project team demonstrated the value of the NASA fire data by comparing ground and satellite fire data in Florida, showing regions where remotely sensed data could enhance the current area burned and emissions data. The project team presented results at the EPA-NOAA 50th Anniversary Symposium.

In addition, the team supported numerous interagency activities that demonstrated NASA's commitment, roles, and contributions to the air quality community:

- The NASA Air Quality team participated in the development of a landmark international, public/private report *Improving Emission Inventories for Effective Air Quality Management across North America* (NARSTO-05-001). The report examines the current state of inventories in the U.S., Canada, and Mexico, and it provides recommendations for reducing uncertainties, improving compatibility of data and user access, and developing emissions projections. NASA-sponsored Air Quality team scientists (Stefan Falke, Jim Szykman, and Doreen Neil) were among the authors. *http://narsto.org*
- February 2005. NASA participated in EPA's 2005 National Air Quality Conference, which attracts hundreds of national, state, and local air quality forecasters and managers. NASA addressed the audience in plenary to describe the AQ program, give recent results, and introduce upcoming NASA solicitations. This conference also conducted workshops, including a tutorial on how to use MODIS and GOES aerosol optical depth products to support air quality forecasting. *http://airnow.gov*
- May 2005. NASA participated in the Integrated Earth Observation System (IEOS) Public Engagement Workshop *Continuing the Dialogue*. NASA AQ team members supported the air quality near-term opportunity breakout session, including serving as rappateur.
- June 2005. NASA participated in the interagency BlueSkyRAINS (BSR) annual meeting to support planning efforts for BSR evaluation during the 2005 fire season. NASA announced the selection of the BSR-related Decisions CAN proposal to introduce MODIS products into BSR; the PI and several Co-Is and Collaborators were at the meeting. *http://www.blueskyrains.org*
- June 2005. NASA attended a meeting of the Task Force on Hemispheric Transport of Air Pollution within the Executive Body for the Convention on Long-range Transboundary Air Pollution (LRTAP). U.S. EPA serves as a Co-Chair of the Task Force. The meeting addressed three main topics – Observations, Emission inventories and projections, and Regional and global modeling – and the committee proposed to work on an assessment of hemispheric transport in 2005-2009 through a) models, inventories and data intercomparison and evaluation and b) model- and observation-based assessments. A NASA representative attended to identify opportunities for Earth science results to contribute to U.S. interests in LRTAP and will continue to support EPA and U.S. representatives in this activity. *http://www.htap.org*
- Summer-Autumn 2005. NASA participated in the U.S. GEO Near Term Opportunity Working Group on Air Quality. This interagency team developed a white paper to identify priorities for integrated activities that draw on key agency systems for air quality. The five priorities included Integrated Observation-Model Air Quality Fields, Systems for Utilizing Observations to Improve AQ Forecasts, Assessments of Key Air Quality Processes, Improved Emissions Inventories, and Improved International Transport Assessments. Members of the team will present the priorities to OMB, OSTP, and U.S. GEO in FY06. *http://usgeo.gov*
- September 2005. NASA Air Quality team members and USDA representatives met at NASA-Goddard to discuss opportunities for NASA Earth science results to support USDA Air Quality activities. The meeting identified ammonia as a key issue facing USDA. Following the meeting, NASA compiled an assessment of NASA's projects and Earth science results related to ammonia/ammonium for further activities with USDA in FY06.

SOLICITATIONS

Decisions CAN

The Air Quality Program received 27 Step-1 proposals in the Decisions CAN and encouraged 10 to submit full proposals. In Step-2, the Air Quality program received 11 full proposals, including 3 that overlapped significantly with the Disaster Management program.

Following the panel reviews and internal assessment for programmatic balance, the Applied Sciences Program selected two Air Quality proposals for awards (the first in conjunction with the Public Health program, the second with the Disaster Management program):

> Three-Dimensional Air Quality System
> *PI: Ray Hoff, University of Maryland-Baltimore County*
>
> Enhancements to the BlueSkyRAINS Emissions Assessment and Air Quality Prediction System
> *PI: Dana Sullivan, Sonoma Technology, Inc.*

The Applied Sciences Program later selected additional proposals for one-year awards from a Congressionally-directed augmentation, including one project for the AQ program's portfolio:

> Use of Satellite Data to Improve the Physical Atmosphere in SIP Decision Making Models
> *PI: Richard McNider, University of Alabama-Huntsville*

ROSES 2005 – Section A.24

For the Applied Sciences portion of the ROSES 2005 NRA, the Air Quality Program received 10 Step-1 proposals and encouraged 9 to submit full proposals. The Step-2 proposals were due in November 2005 with selections expected by April 2006.

PUBLICATIONS (SELECTED)

Al-Saadi, J., J. Szykman, R. B. Pierce, C. Kittaka, D. Neil, D. A. Chu, L. Remer, L. Gumley, E. Prins, L. Weinstock, C. MacDonald, R. Wayland, F. Dimmick, and J. Fishman, 2005: Improving National Air Quality Forecasts with Satellite Aerosol Observations. *Bulletin of the American Meteorological Society*, 86, 1249-1261).

Falke, S., and S. Ambrose (2005) "Seeing Through Smoke – Earth Observations Enhance Fire and Smoke Decision Support Systems in the Eastern United States" *Earth Observation Magazine*, vol. XIV, no. 6.

Friedl, L., NASA Air Quality Program Team, 2005: Space-based Earth Science Support for Air Quality Management. *EM*, September, 28-32.

Friedl, L., D. Neil, R.B. Pierce, NASA Air Quality Program Team, 2005: Air Quality Management through Earth Observations & Models. *Earth Observation Magazine*, XIV.

Hutchison, K. D., Smith, S. and S. Faraqui, 2005: Correlating MODIS Aerosol Optical Thickness Data with Ground-Based PM2.5 Observations across Texas for Use in a Real-time Air Quality Prediction System, *Atmospheric Environment*. 38, 7190-7203.

Keith D. Hutchison, Tatyana Pekker, and Solar Smith: Improved Retrievals of Cloud Boundaries with MODIS Data for Use in Air Quality Modeling. *International Journal of Remote Sensing*, in press.

Song, C.-K., D. W. Byun, R. B. Pierce, F. Vukovich, A. Gilliland, A. Al-Saadi: Developing a downscaling method from global to regional ozone modeling: Application for linking RAQMS and CMAQ. *Proceedings of SPIE*, Volume: 5890, p250-258, 2005.

CONFERENCE/WORKSHOP PRESENTATIONS AND POSTERS (SELECTED)

Chu, D. A., "Satellite observations for air quality application," invited seminar at The Center for Global and Regional Environmental Research and Department of Geography, Clyde Kohn Colloquium, University of Iowa, September 9, 2005.

Remer, L.A., Y.J. Kaufman, D. Tanré, S. Mattoo, R.G. Kleidman, R. Levy, J.V. Martins, D.A. Chu, C. Ichoku, R-R. Li, I. Koren, "Towards a global aerosol climatology using MODIS observations." Presented at the MODIS science team meeting, January 2005.

Remer, L.A., "Satellite observations of long range transport of air pollutants." Presented at the *1st Workshop of the Hemispheric Transport of Air Pollution* sub-committee, Brussels, June 2005.

Soja A.J., J. Al-Saadi, J.J. Szykman, W.R. Barnard, C. Kittaka, T. Pace, D.J. Williams, J. Kordzi, and R.B. Pierce. Invited talk, National Regional Planning Organization Technical Meeting, Denver, *Using Satellite-Based Data to Estimate Fire Frequency and Area Burned in the United States*, June 2005.

PUBLICATIONS RELATED TO AIR QUALITY BY NASA AIR QUALITY RESEARCHERS (SELECTED)

Chu, D. A., L. A. Remer, Y. J. Kaufman, B. Schmid, J. Redemann, K. Knobelspiesse, J.-D. Chern, J. Livingston, P. Russell, X. Xiong, W. Ridgway, Evaluation of aerosol properties over ocean from MODIS During ACE-Asia, *Journal of Geophysical Research*, 110, D07308, doi:10.1029/2004JD005208, 2005a.

Ichoku, C. and Kaufman, Y. J.: A method to derive smoke emission rate from MODIS fire radiative energy measurements, *IEEE Transactions on Geoscience and Remote Sensing*, 43, 2636-2649, 2005.

Kaufman, Y. J., Koren, I., Remer, L. A., Tanré, D., Ginoux, P. and Fan, S.: Dust transport and deposition observed from the Terra-MODIS spacecraft over the Atlantic Ocean., *Journal of Geophysical Research*, 110, D10S12, doi:10.1029/2003JD004436., 2005.

Kaufman, Y. J., Boucher, O., Tanré, D., Chin, M., Remer, L. A. and Takemura, T.: Aerosol anthropogenic component estimated from satellite data., *Geophysical Research Letters*, 32, L17804, doi:17810.11029/12005GL023125, 2005.

Levy, R. C., Remer, L. A., Martins, J. V., Kaufman, Y. J., Plana-Fattori, A., Redemann, J., Russell, P. B. and Wenny, B.: Evaluation of the MODIS aerosol retrievals over ocean and land during CLAMS, *Journal of the Atmospheric Sciences*, 62, 974-992, 2005.

Li, C. C., Lau, A. K. H., Mao, J. T. and Chu, D. A.: Retrieval, validation and application of the 1-km aerosol optical depth from MODIS measurements over Hong Kong., *IEEE Transactions on Geoscience and Remote Sensing*, 43, 2650-2658, 2005.

Li, R.-R., Remer, L., Kaufman, Y. J., Mattoo, S., Gao, B.-C. and Vermote, E.: Snow and ice mask for the MODIS aerosol products., *IEEE Geoscience and Remote Sensing Letters*, 2, 306-310, 2005.

Remer, L. A., Kaufman, Y. J., Tanré, D., Mattoo, S., Chu, D. A., Martins, J. V., Li, R.-R., Ichoku, C., Levy, R. C., Kleidman, R. G., Eck, T. F., Vermote, E. and Holben, B. N.: The MODIS aerosol algorithm, products and validation., *Journal of Atmospheric Science*, 62 (4), 947-973, 2005.

CONTACT INFORMATION

Lawrence Friedl, Program Element Manager
Telephone: 202-358-1599
E-mail: LFriedl@nasa.gov

Doreen Neil, Deputy Program Element Manager
Telephone: 757-864-8171
E-mail: Doreen.O.Neil@nasa.gov